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Scoliosis: A Literature Review

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Abstract

Scoliosis is a condition in which the spine has a lateral curve and rotation, which can cause prominence of the thorax, shoulder blade, shoulders and pelvis are asymmetrical. It is more common in adolescent females and usually has no known cause. Scoliosis in young children is more likely to have a known cause. Risk factors for progression include: type of abnormality, location of abnormality, and patient age. Plain radiographic images are still the standard for diagnosis. MRI evaluation may be considered. Scoliosis management aims to achieve body and spinal balance while maintaining as much normal spinal growth as possible and preventing neurological deficits. Treatment focuses on identifying and monitoring curves that may worsen and treating them if necessary.

Keywords: Spine, Scoliosis, Deformity, Review.

INTRODUCTION

Scoliosis is a deformity of the spine has a lateral curvature of more than 10 degrees. There are different types of scoliosis, such as idiopathic and secondary, and it can also be classified by the side of the curve and the age at which it occurs [1]. The prevalence of scoliosis ranges from 2-13.6% across different countries [2,3]. The rate of occurrence of adolescent idiopathic scoliosis among students aged 9-16 in Surabaya, Indonesia elementary and junior high schools is 2.93% out of a total of 784 students [4]. Scoliosis is still considered as idiopathic condition, but it is thought to be influenced by a mixture of genetic, growth, hormonal, and neurological factors, as well as changes in *bone mass density* (BMD), abnormalities in body tissue, and imbalances in certain chemicals in the body [5].

Scoliosis can be treated by addressing the underlying cause. The treatment of scoliosis depends on understanding the natural mechanism of the curve and its complication [6]. However, it's important to note that there is no exact characteristic of the illness, but rather varying subjective complaints that can vary depending on the type of curve [7]. This literature review discusses on various forms of scoliosis, the potential for the condition to worsen, and the methods used for evaluating and treating scoliosis.

Natural History of Scoliosis

Scoliosis is considered to be a inherited disease with siblings and parents to child coincidence [8]. When first diagnosed, the primary focus is usually determining if the cause is idiopathic or non-idiopathic. Non-idiopathic reasons typically manifest earlier, advance faster, and may exhibit neurological signs [9,10]. Scoliosis typically manifests as a deformity that the patients, their family, or friends first notice. This deformity may be a curvature of the spine, rib protrusion, or an asymmetry of the pelvis or shoulders [7]. In adolescent females, breast asymmetry may also be noticed. Pain is not a common symptom of scoliosis, but some patients may experience back pain or pain from rib prominence [2].

Pain should alarm the clinician to exclude spinal infections, particularly if the patient complains about fever. Imaging should be ordered to rule out a spinal tumor because nighttime pain in one location is uncommon. Other crucial characteristics to be aware of include imbalance and gait disturbance, poor or paralysis of bowel and bladder, and any other neurological deficits, as these can indicate other pathological causes, such as tumors or central causes like syringomyelia [1]. The risk of deterioration depends on the timing of growth spurts and how much growth left in each patient, so curve deterioration needs to be closely monitored.

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Untreated severe or deteriorating scoliosis in younger children can cause burden the respiratory system [6].

The patient's perception of their appearance is also crucial in therapeutic planning, as unhappiness with self-image could eventually result in psychological impairment. Long-term scoliosis results are primarily based on observational studies involving diverse patient populations; generally, curves over 90 degrees are thought to increase the risk of morbidity and mortality [11]. If not properly treated, these consequences in curves with congenital or early onset can be disastrous [6]. Scoliosis in adults can arise spontaneously, usually as a result of a degenerative disease, or it can be brought on by an untreated or overlooked adolescent deformity [12]. Treatment goal in all cases is to prevent curve progression [7] .

Upon spinal physical examination, a severe form of scoliosis would be easily noticeable without much of an effort, even with clothing. For milder form, disrobing the patient would be necessary. Through inspection, shoulder and pelvic should appear level, as well as spinal process' protrusion. Palpation gives examiner more detailed contour of the back. Spinous processes from cervical to coccyx needs to be palpated to feel the alignment. Forward bending test or Adam's forward bend test is an exam specifically designed to recognize any coronal tilt of patient's posture. To measure the angle of the tilt, a scoliometer can be placed on the apex of the spinal curvature (Figure 1) [6].

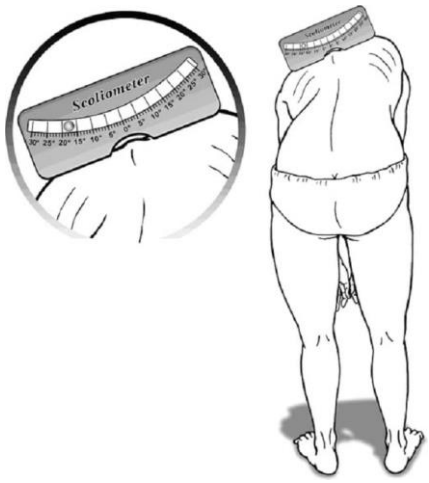

Figure 1: Forward bending test and angle measurement with scoliometer

Classification

Scoliosis can be classified based on the cause, such as idiopathic (primary) or secondary. Idiopathic scoliosis is divided into subtypes based on age of onset, such as infantile, juvenile, and adolescent or early and late onset. It can also be caused by other underlying medical conditions like congenital disorders, neuromuscular conditions, tumours, trauma, or syndromic conditions [1,6,10]. Additionally, scoliosis can be classified by the side of the curve, whether it is left or right sided [7]. Scoliosis curves can be further classified based on the apical vertebral level as seen in Table 1.

Table 1: Scoliosis classification by apex location [5,7].

Cervical	C1-C6
Cervicothoracic	C7-T1
Thoracic	T2-T12
Thoracolumbar	T12-L1
Lumbar	L2-L4
Lumbosacral	L5-S1

The different types of scoliosis are as follows:

1. Idiopathic

a. Congenital scoliosis

Congenital scoliosis curves present at birth but may not be noticeable for many years. Genetic mutations in the HOX group are the cause for many cases. These types are classified into three groups: failure of formation, failure of segmentation, and mixed groups. Each group is further divided based on the location of the pathology. The classification helps to understand the natural progression of these curves. Generally, failures of segmentation have a more favourable outcome compared to failures of formation and mixed anomalies. The prognosis is generally worse for anomalies in junctional regions, like the thoracolumbar junction. These curves are usually associated with neurological, cardiac, and urinary anomalies and are often discovered through a prenatal ultrasound [6]. Congenital scoliosis can range from minor to severe depending on the probability of progression and the chance of spinal cord compression and paralysis. It is advised that children with congenital scoliosis have brain and spinal cord MRIs (magnetic resonance imaging), as about 20% of cases have abnormalities in these areas. Conditions such as Chiari malformations, Syringomyelia, and spinal cord tethering are commonly associated with congenital and earlier onset of the disease [1]. Other factors that may be associated with congenital scoliosis include old age, an increased incidence of congenital heart anomaly, hip dysplasia, and disabilities. Additionally, conditions such as Diastematomyelia and VACTERLS syndrome may be associated with congenital scoliosis. Plagiocephaly and rib malformations may also be present and can indicate that the scoliosis was caused by intrauterine molding [7].

b. Infantile and juvenile scoliosis

Curves that develop in children between the age of 0-3 and 4-10 years are referred to as infantile and juvenile idiopathic scoliosis, respectively. Recently, curves that occur before the age of 10 years have been referred to as having "early onset" [10]. Children with earlier onset of the deformity are at a higher risk of impaired lower respiratory system, which can impact their life expectancy. The risk of respiratory complications is identified by measuring the rib-vertebral angle difference (RVAD) and comparing it to the Cobb angle [13]. If the difference between the two angles is more than 20 degrees, it suggests a likelihood of deterioration. Therefore, it's important to measure both angles in these patients. If the Cobb angle is less than 25 degrees and RVAD is less than 20 degrees, they should be observed every 4-6 months with radiographs. If the Cobb angle increases by 5-10 degrees independent to the changes to RVAD, then treatment is recommended [7]. Early intervention aims to improve lung development, encourage healthy spine growth, and stop the progression of deformity, control the spine and thoracic cavity [14].

c. Adolescent scoliosis

Adolescent idiopathic scoliosis is the most common form of scoliosis seen, accounting for about 80% of cases [2]. The incidence of small curves is equal in both sexes, but larger curves are more common in females. These curves frequently appear when the disease has advanced to the point where a other people observes asymmetry in the shoulder, waist, or back. Adolescent idiopathic curve progression risk can be predicted by several factors, including first presentation magnitude of the curves, the presence of double curves, and the rate of growth during the adolescent growth spurt. Premenarchal status and skeletal immaturity, as assessed by the Risser grade, also increase the potential for progression [15]. However, the likelihood of progression decreases as growth slows down following the onset of menarche in girls and puberty in boys [7]. Two classification systems have been developed to determine the fusion area for these types of curves: the King & Moe classification,

which describes five distinct curve patterns but has poor intra/inter observer reliability and only evaluate the coronal plane, and the Lenke system, which combines six curve types with coronal and sagittal plane modifiers and identifies minor and major structural curves [15]. Figure 2 shows the Lenke classification system. Nevertheless, not all curves fall into these categories, and each curve should be treated according to its own merits because it might be necessary to combine treatment approaches [1].

Lenke classification system is used to classify scoliosis based on the type of curve and its location in the spine. It includes 6 curve types, a sagittal thoracic and a lumbar spine modifier. These definitions were established by the Scoliosis Research Society and are used to order appropriate vertebral levels for an arthrodesis. The classification system is based on the location of the curve's apex, with thoracic curves having an apex from T2 to T11/T12, thoracolumbar curves having an apex at T12 to L1, and lumbar curves having an apex from L1/L2 to L4. The lumbar modifiers (A, B, and C) are used to indicate the position of the lumbar curve apex in relation to the center sacral vertical line (CSVL). Type A is when the line is between the pedicles on apical level of the lumbar, Type B is when the CSVL touches the apical vertebral body, and Type C is when the CSVL is completely medial to the vertebral body. The thoracic sagittal modifier describes the degree of thoracic kyphosis between T5 and T12, with less than 10 degrees being designated with a "-", more than 40 degrees designated with a "+", and "N" indicating a kyphosis between 10 and 40 degrees [16].

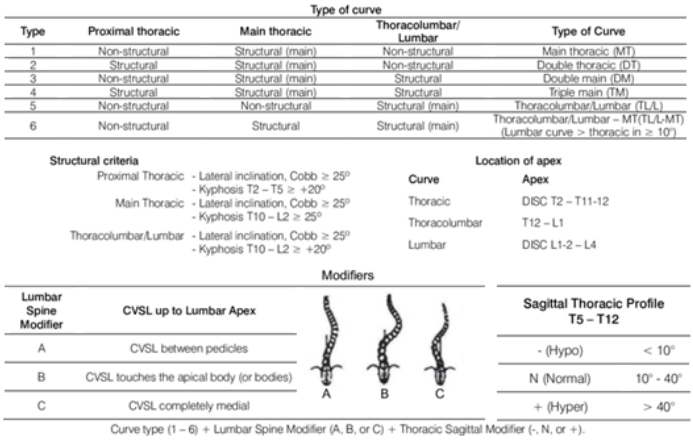

Figure 2: Lenke classification system for adolescent idiopathic scoliosis [16].

2. Neuromuscular scoliosis

Neuromuscular scoliosis is a type of scoliosis triggered by neurological or muscular conditions that disrupt the normal alignment and support of the spine. In the past, Polio was the main cause of this type of scoliosis, but presently, the most common causes are Cerebral Palsy and Spina Bifida [17]. This type of scoliosis is also seen in various progressive neuromuscular disorder such as Duchenne muscular dystrophy and Spinal muscular atrophy. Children with neuromuscular scoliosis often present with muscle coordination and sitting difficulties rather than pain, and as their trunk muscles weaken, their spine gradually collapses, resulting in a long, C-shaped curve. These curves are often progressive, worsening at periods of rapid growth like puberty, particularly in children with severe CP [18,13]. Children with GMFC 4 and 5 need close monitoring by pediatricians and physiotherapists to detect scoliosis, and specialist surgeons use sitting or standing X-rays to monitor the progression. Progressive curvature might make it difficult for children who are wheelchair-dependent or immobile to sit comfortably [19]. Lung issues, such as volume loss and recurring infections, are more prevalent in people with severe deformities and are more common in people with thoracic spine curves of 80 degrees or more [20].

3. Developmental or syndromic scoliosis

Syndromic scoliosis refers to a type of scoliosis that is associated with various syndromes, including skeletal dysplasias, connective tissue disorders, and neuromuscular conditions [7]. Examples of common syndromes that can cause scoliosis include neurofibromatosis and Marfan syndrome, as well as Rett syndrome, Prader-Willi syndrome, osteogenesis imperfecta, and Ehler-Danlos syndrome. Children with syndromic scoliosis tend to have worse risk of medical complications and complications from surgery when compared to children with idiopathic scoliosis [21,22].

Scoliosis is not a common occurrence in type 2 Neurofibromatosis (NF), but it can happen in 10-40% of patients with type 1 NF. There are two types of scoliosis associated with NF: 1. Dystrophic scoliosis, which is typically a severe, short curve with a significant kyphosis. 2. Non-dystrophic scoliosis, which is alike to an idiopathic curve. An MRI is needed to rule out the presence of an intraspinal neurofibroma, which is more abundant in dystrophic curves [23]. Treatment may require a combination approach as pseudoarthrosis is a known complication of scoliosis associated with neurofibromatosis[24].

Clinical Assessment

It is crucial to have a thorough medical history. Include the time of start and the person who first noted the curvature when diagnosing scoliosis, as well as any history of progression or pain [7]. Pain may be an indication of an underlying pathology, such as tumors, neurological conditions, or syndromic conditions like Arnold Chiari malformation or cord tethering. The onset of menarche in females and the characteristics of puberty in males are significant indicators for determining the likelihood of deterioration and the interventions timing. Obtaining specifics about the deformity's secondary effects is necessary, such as issues with body image or functional restrictions at school due to coordination or cardio-respiratory problems [25]. A birth history, family history, and examination must contain height and weight measurements, as well as observation for skin stigmata, lower limb anomalies, dysmorphic facial features, shoulder or pelvic asymmetry, truncal balance, scapular prominence, flexibility of the curve, thoracic kyphosis, lordosis, range of motion, gait pattern, and a full neurological examination [1,6]. In younger children, the spine can be examined while the child is suspended in the air to check for flexibility and pelvic obliquity, as well as while the child performs everyday activities like walking and squatting. Always check the lower extremities for deformity or length discrepancies [26].

A scoliosis is characterized by two curves, a primary and a secondary curve, each with a convex and concave side. The primary curve is typically more rigid and its location on cervical, thoracic, or lumbar depends on where vertebral apex lies in the coronal plane. A junctional curve appears where two areas converge. The end vertebrae are the most cephalad and caudal vertebrae with surfaces that incline toward the concavity of the curve, and the apical vertebra is the most rotated vertebra in the curve. The Cobb angle, which is typically expressed in the concavity direction, is used to calculate the curve size. The Cobb angle is helpful in evaluating the first curve, tracking the curves' escalating magnitude, and determining when an operative intervention might be most advantageous for the child. Unlike the Cobbometer, which was previously in use, this measurement can be performed using computer software [27, 28].

In young children, the Adams forward bending test (to identify the prominence of the rib on the thoracic or transverse process on the lumbar spine) may not be possible. However, the test can be simulated by placing the child in a prone position on the examiner's knees. The flexibility of the curve can be examined by placing the child in a lateral position on the examiner's knees or by holding the baby on the examiner's arm. The balance of the spine in the coronal and sagittal

dimensions should be evaluated. Truncal imbalances, head tilt, shoulder asymmetry and pelvic balance should be evaluated. Motor, sensory and reflex (including abdominal reflexes) examination should be done thoroughly [6, 7]. Vital capacity screening is recommended for patients with severe curves. Treatment is recommended if surgery is planned for patients with a vital capacity less than 60% of normal [14].

Radiological Examinations

Plain X-rays are the foundation of initial assessment, in addition to physical examination, and are widely available and inexpensive. They are also useful for monitoring the curve. However, standard X-rays are not sufficient at the initial appointment, a standing PA and lateral views of the entire spine are required for assessing adolescent scoliosis. On subsequent visits, only a PA view is necessary to diagnose congenital deformities and assess the sagittal profile [29]. Additional views, such as supine active bending films to examine curve flexibility, traction views in neuromuscular or syndromic patients who are unable to bend actively, hyperextension views to assess flexibility in kyphotic deformities, and the Ferguson view which allows assessment of the L5-S1 junction. In wheelchair-bound patients, sitting films will reveal pelvic obliquity and spinal deformity [30].

It is measured how severe the curve is and how it changes over time by the Cobb angle [31]. The maturity of the skeletal structure can be estimated by the ossification of the iliac apophysis, from front to back, which is graded using the Risser classification (1-5). A Risser 5 represents complete skeletal maturity and no further growth. Grade 0-2 have the maximum risk of progression should be closely monitored, and radiation exposure should be minimized, so X-rays should only be taken when clinically necessary. A PA film reduces radiation exposure. In some institutions, superficial topography of the back is used to monitor curves instead of X-rays to reduce radiation exposure [7].

Magnetic Resonance Imaging (MRI) of the complete spine is recommended for all infant and children with large or progressive curves, as around 25% of these patients may have neuroaxial anomalies. These anomalies may include Arnold-Chiari malformations, syrinx, tumors and cord tethering. The use of MRI in young patients is more debated due to the low rate of abnormalities detected. Congenital scoliosis, pain, rapid curve progression, a left-sided thoracic curve, and neurofibromatosis are all indications for an MRI. The entire spine, including the cranio-cervical junction, should be scanned [32, 33, 34].

Computed tomography can be helpful for planning surgeries for complex cases by showing the bony anatomy. It is especially useful for children with small or absent pedicles, as this information can be used to plan alternative forms of stable fixation. Children with congenital conditions should undergo an echocardiogram and a renal ultrasound as part of their pre-operative planning because these children are more likely to have cardiac and renal anomalies [35, 36]. As bronchio-alveolar development continues until the age of 8, it is also crucial to evaluate respiratory function in younger children. For older, more cooperative patients, measuring forced vital capacity as a percentage of normal can be a useful guide to pulmonary function [7].

Treatment

The treatment for curves over 20 degrees in all groups, additional follow-up is usually necessary. A 5 degree increase in curve size within a 6-month period or a 10-degree increase within a 12-month period is regarded as progression. When there is progression or if the curve is significant upon initial presentation, treatment should start. Surgery can be the initial treatment of choice in circumstances where deteioration with serious consequences is anticipated, such as in congenital deformities [1, 7]. With curves between 20 and 40 degrees, observation or bracing may be a viable option for older kids. A growth spurt, growth potential, curve pattern, curve magnitude, unusual curve pattern, thoracic hypokyphosis, and female sex are risk factors for severity. The objectives of treatment include halting the progression of the curve, achieving satisfactory coronal and sagittal correction, enhancing aesthetic appeal, achieving solid fusion, and avoiding long-term disability [28].

1. Conservative treatment

Bracing and casting are recommended for younger children and are less certain for adolescents. The goal is to keep the curve stable up until the child reaches skeletal maturity. As the brace must be worn for up to 23 hours per day, the results of bracing are less certain than those of surgery and heavily dependent on the child's compliance [7]. Under general anesthesia, a cast is applied to young children with flexible curves; it must be changed frequently every 3-4 months to accommodate growth. Once the curve is under control, which typically takes 12-18 months, a molded brace is worn for until skeletal maturity [37]. In stable patients, the brace can be gradually discontinued as the child nears maturity. If bracing is unsuccessful, surgery should be considered [9]. Table 2 shows the various methods of conservative approaches for scoliosis.

Table 2: Conservative treatment options [9, 38, 39, 40]

Milwaukee brace	This brace is used for postoperative treatment of post-polio scoliosis, it includes a pelvic section (usually plastic), front and back uprights, and a neck ring with a throat mold in the front and occipital pads in the back. It is commonly used for patients with a curve apex higher than T8. Another type of brace used to treat scoliosis is the TLSO, which was first used for patients with deteiorating AIS and a curve apex below T8
Boston brace	It is commercially available in six sizes to increase production efficiency. This is a back-opening TLSO that passively corrects the scoliotic curve.
Cheneau brace	The brace has two modes of operation, active and passive, and while the goal of using orthotics to treat scoliosis is to prevent the curve deteioration, the Cheneau brace may actually correct the curvature in some instances.
Rigo Cheneau brace	This brace is generally recommended for individuals with mild to moderate pediatric scoliosis. It is built on the idea of balance at the L4/L5 level. Studies have shown that it can achieve a 53.7% correction of the main curvature, but for patients with a single extended dorsal curvature, the correction rate increases to 76.7%, and 55% for those with rotational deformity cases.
Gensingen brace	This brace is utilizing computerized design and is typically used for curvatures of more than 50 degrees, which cannot be treated with other orthotics.
Cheneau-Toulouse-Munster brace	This is is a type of thoracolumbosacral orthosis (TLSO) that opens in the front and exerts pressure on the torso to change the scoliotic curve and disallowing it from getting worse. It is usually worn at night, particularly for low curvature (Cobb angle less than 30).
Triac brace	The Triac brace is designed to provide dynamic force to treat scoliosis. Because of the hinge position, it can only be used for curves below T11. The name Triac is based on the three C's: comfort, control, and cosmesis. The design focuses on the brace following the patient's motion. It has the unique feature of being able to achieve an instant correction of 22% for the primary curve and 35% for the secondary curve.
C-brace	The C-brace is a type of orthosis that addresses single curve deformities. Its design allows for movement of the trunk, providing patients with increased ease while wearing the brace.
Scoliosis Lycra orthosis	The Scoliosis Lycra orthosis is intended for individuals with neurological scoliosis. It consists of a panel that is added to

	the convex side of the brace to slow the deterioration. This orthosis is primarily for patients with cerebral palsy.
SpineCor orthosis	The SpineCor brace is designed with an active biofeedback mechanism, and has been found to be effective for minor scoliosis curves.
Charleston brace	The Charleston brace is a custom orthosis that positions the patient in an overcorrection. Studies have shown that by wearing the brace for 5-10 hours a day, it can change the course of the scoliosis over time.
Long lever scoliosis brace	This brace is intended to address large translational displacement related to idiopathic scoliosis. The force required to stabilize the curve decreases with the use of its long lever arm system.
Providence brace	The Providence brace is an orthosis that is worn at night. It is designed to put the spine in an overcorrection by applying opposing forces, and is intended to address abnormalities.
Sforzesco brace	This is a non-casting alternative, particularly for severe cases, and is based on the SPoRT (symmetric patient-oriented, rigid three-dimensional, active) concept. It is made of two pieces of polycarbonate that are connected in the front and back by a closure and a vertical aluminum bar respectively.
Lapadula brace	The Lapadula brace is similar to the Sforzesco brace in that it is made of polycarbonate. The main difference is that the Lapadula brace does not have an above chest pad. It is primarily recommended for patients with both hyperkyphosis and scoliosis.
Dynamic derotational brace	This is a modified version of the Boston limited pressure brace, features its lightness and flexible aluminum blades. Studies have shown that this brace not only slows the deteioration of the curve, but also corrects it. It can be created using traditional casting methods or computer-aided design and manufacturing technology (CAD-CAM).
Progressive Action Short Brace	The design is based on the idea that scoliotic spines can be corrected by reversing the abnormal load distribution during growth.
Spinealite soft brace	Also known as the CMCR brace (Correct Monocoque Carbone respectant la Respiration) is a monoshell brace. Unlike traditional pads, the pads of this brace are mobile and comfortable. The brace is lightweight and reinforced with carbon blades and can be made without casting
ART brace	The ART brace is a spinal orthosis that was developed using computer-aided design and manufacturing (CAD-CAM) technology. The software (OrthenShape) allows overlaying different CAD-CAM modulus. The brace is based on the Lyon approach, and the acronym ART stands for Asymmetrical, Rigid, Torsion brace.
Lyon brace	This is an adjustable, active, decompressive, symmetrical, stable and transparent orthosis. It is designed to stretch the ligaments of the spine by using a plaster cast for 4 weeks, allowing for up to 7 cm of growth. It is mostly recommended for use during the night to maintain the structure. It is typically not recommended for patients with juvenile or infantile scoliosis, severe thoracic lordosis, major psychological reactions or nonacceptance of the plaster cast.
Wilmington brace	The Wilmington brace is a custom-made spinal orthosis that is designed to be less bulky and lightweight than other similar braces. It is made from orthoplast, and features an anterior opening, adjustable straps, and is intended to be worn for 23 hours per day. It is intended to improve patient compliance by making the brace more comfortable to wear. The scoliosis brace can also be divided into soft and rigid orthoses, and can be classified based on the time of wear

2. Surgical treatment

Surgery is generally recommended for scoliosis when the deformity exceeds 45 or 50 degrees as measured by the Cobb method. This is due to these considerations: [7, 14].

a. Curves larger than 50 degrees tend to continue to progress even after the skeleton has finished maturing. For example, thoracic curves between 50 and 75 degrees at skeletal maturity deter at an average rate of 29.4 degrees over a 40.5-year follow-up period. Curves more than 55 degrees at maturity progressed more than 0.5 degrees per year [14].

b. Larger curves can cause a loss of lung function and even respiratory problem. For example, in patients with curves between 60 and 100 degrees, total lung capacity was 68% of normal values. Half of patients with thoracic curves larger than 80 degrees experienced shortness of breath at an average age of 42 years [14].

c. It is more challenging to surgically treat curves that are larger. This could result in a need for more surgical anchors, a longer procedure, more blood loss, and a higher rate of surgical complications [14].

The patient's decision to have surgery to straighten their spine should sometimes be respected, especially in cases where the Cobb angle is between 40 and 45 degrees. Surgery is typically more aggressive for younger patients as scoliosis is a disorder that is related to growth [6, 7]. Congenital, neuromuscular, and syndromic curves are more likely to need surgery than other types. Surgery's objectives are to stop the curve from advancing and to treat the malformation in the coronal and sagittal axis. A short or long fusion may be necessary for this. The impact of a fusion on the spine's capacity for growth must be considered. Between the two periods of rapid spinal development 0–5 years and 10–16 years spinal growth is constant. After spinal fusion, the potential shortening can be calculated using the following formula: 0.07 x fused segments multiplied by the years of growth left (cm) [7].

This allows for an approximate calculation of the potential shortening after surgery. The surgical treatment options for infantile and juvenile patients and adolescents are as follows: [7, 14].

Surgical options for scoliosis are divided into onset of the disease. In early onset scoliosis, expandable implant is more preferable due to the dynamic of the bone growth. Magnetic remotely expandable growing rods that can be expanded in an outpatient setting using magnets (Figure 3), other dynamic system is Shilla rod system, which works in a principle of track and trolley, that allows for matural growth and correction of the spine at the same time (Figure 4). Other dynamic device is Vertical Expandable Titatnium Rib Device (VEPTR) which is a metal rod that is curved to fit the spine and fit vertically while being able to expand as the child grows (Figure 5). Other option inclide definitive fusion of the vertebral bodies and fusionless surgery and placing growing rods [7, 11, 14, 37, 41].

The principle of epiphysiodesis is also been able to be used in correcting scoliosis deformity. By restricting the growth of vertebral body on one side, imbalance of growth will be happen in the patient with an expectation of deformation angle change [14, 37, 41].

Late onset scoliosis surgery doesn't require as much dynamization copared to early onset due to limited growth available for the patient. Anterior fusion - has been considered a treatment option for thoracolumbar and lumbar scoliosis as it can achieve better correction with fewer fusion levels. Additionally, a technique for performing anterior instrumentation for thoracic curves using video-assisted thoracoscopic surgery has been developed. Posterior fusion - with

instrumentation used distraction to apply correction force along the concave side of the curve. Correction is attempted through the use of a rod-rotation maneuver. Modern instrumentation systems utilize more anchors to connect the rod to the spine, resulting in improved correction and fewer implant failures. The current trend in instrumentation is using pedicle screw constructs or hybrid constructs that incorporate pedicle screws, hooks, and wires. A combination of anterior and posterior fusion is a possible technique for late onset scoliosis (Figure 6, Figure 7) [14, 37, 41].

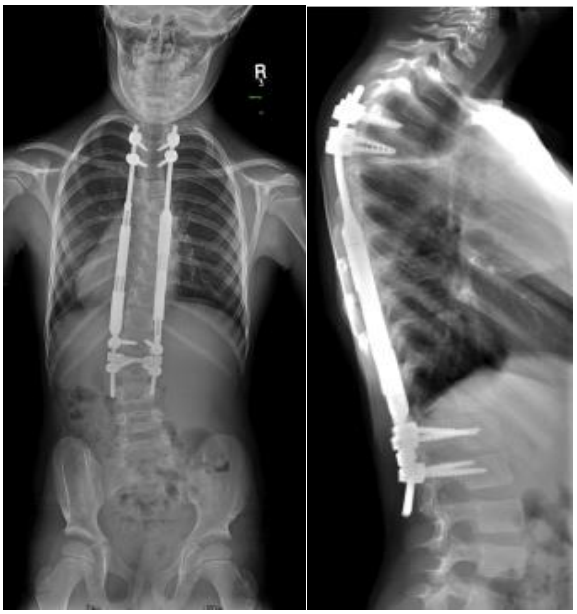

Figure 3: Magnetric remotely expandable system [41]

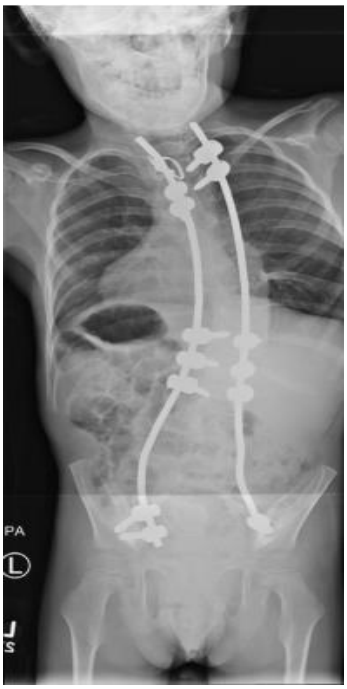

Figure 4: The Shilla Rod System [41]

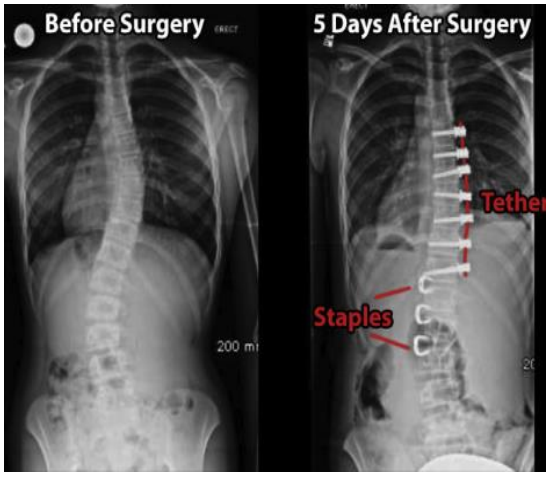

Figure 5: Vertical Expandable Titanium Rib Device (VEPTR) [41]

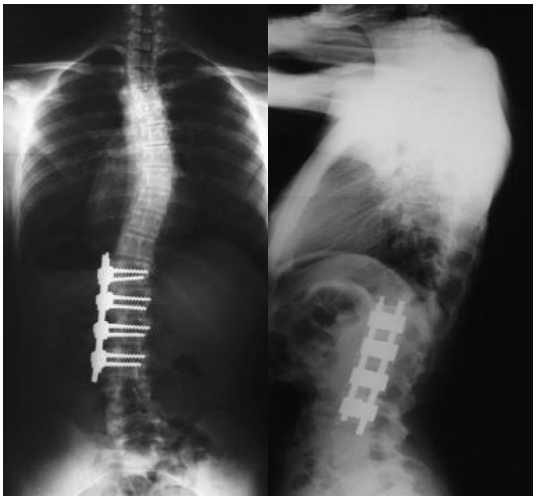

Figure 6: Anterior fusion of the vertebral bodies [14]

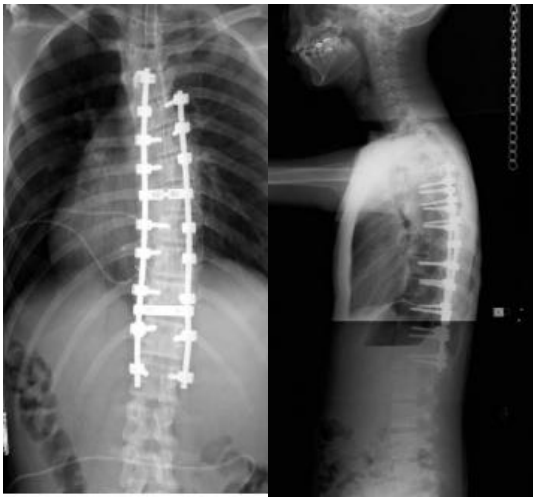

Figure 7: Posterior fusion of the vertebral bodies [14]

Whether to fuse the spine from the front or back during scoliosis surgery depends on factors such as the location, size, and stiffness of the curve. Posterior fusion avoids the chest cavity and potential harm to organs, while anterior techniques result in less blood loss and typically require fusing fewer levels. The surgeon's expertise and experience also determinant of the approach. The chance of permanent nerve damage from the surgery is low, and patients are closely monitored for complications after the procedure [41]. Scoliosis surgery aims to improve

the patient's ability to function and live a normal, active lifestyle without the negative effects of a progressive spinal curve [7, 14, 37, 41].

Complication

Generally without the progression of the disease, scoliosis affect patients' cosmetic through their posture. However, when progressivity occurs, pain progresses, and neurological dysfunction will follow. On severe thoracic scoliosis, breathing problem may also occur due to imbalance pulmonary capacity [40].

Surgical complications of scoliosis surgery may occur from different aspect of the disease. Implant complication include implant failure such as breakage or bending of implants. Infection may also occur from superficial wound complication to deep wound complication. Blood loss from surgery may also occur and create devastating issues on post major spine surgery. Spine related complication can also shown in the form of pseudoarthrosis. Neurological complication is also one devastating complication of spinal surgery. The worst complication that can occur is death, it can be caused by autonomic dysfunction, severe blood loss, or spinal shock. Pseudoarthrosis and infection are two most common complications found on spinal surgery [42].

CONCLUSION

In conclusion, scoliosis is a complex spinal disorder that have a significant negative impact on a person's quality of life. The causes of scoliosis are still a confusion among experts and can vary from structural to neuromuscular. This literature review has provided an overview of the causes, classification, and management of scoliosis. Diagnosing scoliosis typically involves a combination of physical examination and imaging studies. Imaging studies such as X-rays, CT scans, and MRI used to confirm the diagnosis and to measure the degree of the curve. However, it is essential to note that early detection is crucial for the best outcome, and regular screenings are important to identify scoliosis at an early stage. The management and classification of scoliosis is a complex and challenging task in the field of orthopedics.

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Authors' Contribution:

IGNPWP: Expert, concept, review.

F: Writing, review, editing, templating.

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